substances on site, in which case the soil cleanup levels will typically not be met throughout the site from the ground surface to 15 feet below the ground surface. In these cases, the cleanup action may be determined to comply with cleanup standards [WAC 173-340-740(6)(d)], provided the compliance monitoring program is designed to ensure the long-term integrity of the containment system, and long-term monitoring and institutional controls are continued until residual hazardous substance concentrations no longer exceed site cleanup levels [See WAC 173-340-360(8)].

The overall approach at Gas Works Park will be to contain contaminated soils that are accessible (i.e., not under buildings, pavements, or other permanent structures) with a vegetated soil cover (described in Section 4.1.2) and develop institutional controls for the site that will ensure proper long-term management of the residual contamination left on-site. Any contaminated soils encountered during construction or subgrade preparation that cannot be used on site and subsequently covered as specified in Section 4.1.2 will be stockpiled, tested, and manifested for off-site disposal and treatment, as appropriate.

3.5.2 Groundwater

At Gas Works Park, the affected groundwater flows into nearby surface water (Lake Union), and the cleanup level will be based on protection of the surface water. Ecology will approve a conditional point of compliance that is located within the surface water, as close as technically possible to the point or points where groundwater flows into the surface water.

Ecology recognizes the technical difficulties inherent in measuring compliance at the actual locations at the Park where hazardous substances may be released to the surface water as a result of groundwater flow. Therefore, compliance monitoring points will be located upland and measured concentrations extrapolated to the surface water-groundwater interface.

No suitable monitoring points presently exist on-site. Actual locations will be specified in the Compliance Monitoring Plan that will be prepared under WAC 173-340-410.

In order to utilize a conditional point of compliance as outlined above, the following must be met:

- Use of a dilution zone under WAC 173-201-035 to demonstrate compliance with surface water cleanup levels shall not be allowed [WAC 173-340-720(6)(d)(i)].
- Groundwater discharges shall be provided with all known available and reasonable methods of treatment prior to release into surface waters [WAC 173-340-720(6)(d)(ii)].
- Groundwater discharges shall not result in violations of sediment quality values published in chapter 173-204 WAC [WAC 173-340-720(6)(d)(iii)].
- Groundwater monitoring shall be performed to estimate contaminant flux rates and to address potential bioaccumulation problems resulting from surface water concentrations below method detection limits.[WAC 173-340-720(6)(d)(iv)].

4. DESCRIPTION OF THE PROPOSED CLEANUP ACTION

4.1 CLEANUP ACTION COMPONENTS

The proposed cleanup action consists of an engineered soil cover to prevent human exposure to contaminated soils, an air sparging and SVE system for treatment of benzene-contaminated soil and groundwater at the southeast part of the Park, and confirmational monitoring of the modeled natural attenuation of the groundwater at the western part of the Park. The locations of these systems at the Park are shown on Figure 4-1.

4.1.1 Air Sparging With Soil Vapor Extraction

4.1.1.1 Process Description

Air sparging is an in-situ process in which air is bubbled through a contaminated groundwater zone to remove volatile organic compounds such as BTEX (benzene, toluene, ethylbenzene, and xylene). Injected air bubbles move vertically and horizontally through the saturated soil zone, creating an underground air stripping process that removes contaminants through volatilization (Figure 4-2). Volatile compounds exposed to the sparged air convert to gas phase and are carried by the air into the unsaturated zone. SVE is used with air sparging to remove vapors from the unsaturated zone. Soil vapors collected by the SVE system are treated to control emissions of air pollutants.

Air sparging has seen a dramatic increase in use and acceptance in recent years, primarily because of its low cost, simplicity, and potential to greatly reduce remediation periods. In a report on innovative technologies, the U.S. Environmental Protection Agency estimated that air sparging is used 45 percent of the time (relative to other innovative technologies) at sites with contaminated groundwater (Environmental Technology 1997). The American Petroleum Institute (API) has assembled a database containing design and operating information on air sparging systems installed at 59 contaminated sites (Hinchee et al. 1995). Brown and Jasiolewicz (1992) estimated that the time and cost for remediating groundwater contaminated with volatile organic compounds may be reduced by as much as 50 percent using air sparging as compared to conventional pump and treat systems.

4.1.1.2 Description of Air Sparging/SVE System

The air sparging system at the Park will consist of six basic elements:

1. Air injection wells,
2. Air compressors or blowers and air distribution piping,
3. Soil vapor extraction system,
4. Geomembrane cap,
5. Soil vapor treatment, and
6. Groundwater monitoring wells.

Figure

4-1 Plan View of Proposed Air Sparging/SVE System

Figure

4-2 Proposed Air Sparging System Detail

Each of these elements is described in the following sections. The description and sizing of components presented in this section are based on work completed during the FFS and are presented with a conceptual level of detail. More detailed design criteria will be developed and presented in the Engineering Report. Certain specific design elements presented in this CAP may change based on further detailed analysis in the Engineering Report.

Air Sparging Wells

A typical air sparging well is shown on Figure 4-2. The air sparging wells will extend down to the Vashon Till and be constructed of 2-inch-diameter steel pipe. The bottom of each well will consist of 1 to 2 feet of well screen. The sparging wells will be completed by placing a sand or gravel pack around the well screen. A 1-ft bentonite seal will be placed above the sand or gravel pack. The well annulus will then be grouted to the ground surface. The sparge well will be flush at the ground surface with a vault cover to protect the well and piping.

Based on previous reports (RETEC 1998), the sparging system is expected to reduce benzene concentrations at the edge of the treatment zone to levels not greater than 430 µg/L. Preliminary estimates indicate that the area of influence of each sparging well may be as much as 35 feet (RETEC 1998). These estimates do not consider the influence of biological degradation, which will occur in the shallow groundwater zone and overlying unsaturated zone to some extent. As a result, cleanup times and BTEX removal rates may be better than expected.

A conceptual layout of sparging wells is shown on Figure 4-1. The layout shows closely-spaced sparging wells spaced at approximately 15 feet on center along the shoreline, downgradient of the source area. These wells will serve primarily to ensure containment of BTEX contamination and prevent further migration of contaminants to surface water. Performance monitoring wells will be located within the downgradient zone of sparging influence. Approximately three rows of additional wells will be located upland, in and around the original source area of contamination. These upland wells will primarily serve to facilitate cleanup of groundwater and soils in the most heavily contaminated area. The actual well spacing and total number of wells will be determined in the Engineering Report.

Blower System

Air will be injected into sparging wells under pressure with mechanical blowers. A pipe manifold constructed of small-diameter plastic pipe will be used to convey air from the blowers to each well (see Figure 4-1). The manifold will be located below grade and beneath the cover, as shown on Figure 4-3. The static water head above the sparge point, the air entry pressure of the saturated soils, and the air injection flow rate govern air injection pressure. Working pressures on the order of 15 pounds per square inch (psi) are typical. Airflow rates typically used in the field are between 3 to 10 standard cubic feet per minute (SCFM) (Rast 1997).

Figure

4-3 Proposed Soil Cover and SVE System Detail

SVE System

Vapors that are mobilized by air sparging will be controlled by the SVE system, which consists of collection piping and a gas extraction blower. As shown on Figures 4-2 and 4-3, perforated pipe will be placed in gravel-filled trenches. The trenches and piping will be installed directly beneath the geomembrane cover and within the existing Gas Works soil deposits. As shown on the site layout (see Figure 4-1), approximately five trenches will be constructed, running parallel with the air sparging lines. The piping manifold will be connected to the extraction blower, which will pull a slight vacuum beneath the cover and remove gases from the soil. The SVE system, in combination with the cover system, will remove BTEX vapors from the vadose zone and prevent soil gas from migrating to the atmosphere.

Geomembrane Cap

To ensure that the vapor extraction system does not simply pull air from the atmosphere above the trenches, a low-permeability cover must be installed over the entire area of influence. The Park air sparging/SVE system will use a geomembrane liner system, consisting of an HDPE liner and geonet drainage system. The advantages of the geomembrane plastic cover versus clay are low profile (the geomembrane and geonet together are less than ½ inches thick), extremely low permeability, ease of construction, and lower cost. The geonet consists of an open ¼-inch-thick HDPE net that can drain as much water as 18 inches of free-draining gravel. The geonet will drain water that has infiltrated through the overlying clean cover soil. The water flowing off of the geonet will drain to the lower edge of the geomembrane and enter drain rock at the edge of Lake Union. The vegetated cover soil described in Section 4.1.2 will cover the geomembrane/geonet composite as well as the surrounding soils. The geotextile element of the vegetated cover soil will prevent clogging of the geonet.

Soil Vapor Treatment

Soil vapor collected by the SVE system will be piped through a treatment unit located with the blowers on a mechanical equipment pad (Figure 4-1). Soil vapor treatment options to be considered include oxidizers (catalytic, thermal, or electric), biofilters, and carbon.

Monitoring

A number of parameters will be tested to monitor the performance of the air sparging/SVE system. Performance parameters include BTEX concentration, dissolved oxygen (DO), water table elevation, and soil gas vacuum from the SVE system. The unsaturated zone will also be monitored for vacuum pressure to verify that the SVE system is successfully containing and preventing soil vapors from migrating to the atmosphere.

4.1.2 Soil Cover

The proposed cleanup action for the Park includes placing a new vegetated soil cover over unpaved open areas ((~~in~~))beginning with the north-central and southeastern portions (((~~about 5.7 acres~~))) as shown on Figure 4-1. These areas of the Park experience heavy use and show signs of erosion and soil wear. The vegetated soil cover will be at least 12 inches thick and separate Park users from the chemicals of concern in existing surficial soils. The new vegetated soil cover will consist of (from top to bottom):

- Grass turf vegetation layer,
- 12 inches of sandy loam topsoil, and
- Geotextile fabric or geogrid.

The vegetated soil cover will be compatible with the air sparging/SVE system described in Section 4.1.1 and will be placed over the partial geomembrane cap. A typical section of the vegetated soil cover is shown on Figure 4-3.

The grass turf vegetation layer will be a blend of grass seed mixes as approved by the City. The seed mix will be a durable blend capable of withstanding the heavy use associated with the Park in dry late-summer weather. The vegetation layer will minimize surface erosion and improve Park aesthetics. The vegetation layer will be the first layer of separation between Park users and the surficial soils; therefore, the vegetation layer will be a primary contributor to the effectiveness of the soil cover system.

The 12-inch sandy loam soil layer will be a free-draining soil that supports the vegetation layer. The free-draining nature of the soil will minimize surface erosion, improve the vegetation layer sustainability by resisting soil compaction from the heavy Park use, and enhance oxygen transfer to the underlying soils. The top 6 inches of the soil layer will be amended with organic material and approved fertilizers consistent with existing City specifications. The amendments will be tilled into the top 6 inches after soil placement and will enhance the establishment of a sustained vegetation layer.

A nonwoven geotextile or a geogrid layer will be placed over the existing Park deposits before soil placement. The geotextile or geogrid will physically separate the existing soils from the overlying vegetative soil layer, and thus eliminate commingling of these soils. The geotextile or geogrid will also provide a visual barrier that will alert maintenance workers or others if the vegetative soil layer has been compromised. The geotextile or geogrid will not be installed near any existing Park vegetation, and the final design will ensure that both existing and proposed vegetation are not adversely affected by geotextile or geogrid placement.

Before the soil cover is placed, the existing soil surface must be prepared. This subgrade preparation will consist of minor site grading to correct surface water problems (such as ponding or erosion), installation of surface water drainage structures and piping, and installation of irrigation mainlines and some laterals. Also, existing grass and herbaceous vegetation will be removed or, at a minimum, sprayed with an appropriate herbicide to prevent growth through the new soil cover, and the surface will be scarified to enhance air infiltration into the soil. Measures will be taken to ensure that the vegetative cover soil effectively blends with the surrounding vegetated and paved areas. The transition areas will be excavated and tapered so that a berm is not formed at the transition edge that could collect surface water or present a tripping hazard. Contaminated soils encountered during subgrade preparation that cannot be used on site and subsequently covered as specified in Section 4.1.2 will be stockpiled, tested, and manifested for off-site disposal.

4.2 COMPLIANCE MONITORING

Chapter 173-340-410 WAC specifies the following types of compliance monitoring regarding cleanup actions:

- Protection monitoring: Confirm that human health and the environment are adequately protected during construction, operation, and maintenance of the cleanup action
- Performance Monitoring: Confirm that the cleanup action has attained cleanup standards and other appropriate performance standards.
- Confirmational Monitoring: Confirm the long-term effectiveness of the cleanup action once cleanup standards and other appropriate performance standards have been attained.

A compliance monitoring plan will be prepared as part of the cleanup action design report submittal. This plan will address compliance monitoring for soil, groundwater, surface water runoff, waste materials, and construction work environment, and will include a Sampling and Analysis Plan (SAP) and data analysis procedures that meet requirements specified in Chapter 173-340-820 WAC. Compliance monitoring anticipated for the Park site is described in the following sections.

4.2.1 Soil

During construction of the soil cover and air sparging/soil vapor extraction system, excavated soils will be stockpiled and tested to determine off-site disposal or recycling options. After the cover is in place, the condition of the cover will be checked on a regular basis by Park maintenance crews, and an irrigation plan will be developed to ensure the viability of the turf. Contaminated ~~S~~soil generated during any future Park construction projects that cannot be used on site (for example, as fill) and subsequently covered as specified in Section 4.1.2 will be stockpiled and characterized for off-site disposal or recycling (see Section 7).

4.2.2 Water

No dewatering of groundwater is anticipated during construction of the cleanup action. Controls will be established during construction to divert clean surface water runoff away from the construction area and prevent discharges from the work area. After the construction has been completed, a network of monitoring wells will be established over the Park area, including installation of new monitoring wells to supplement the existing well network. The monitoring well locations, testing frequency, and chemical parameters will be specified in the SAP.

4.2.3 Waste Materials

Waste materials encountered during construction will be managed in the same manner as soils, as described in Section 4.2.1.